ORIGINAL ARTICLE

# Color Doppler Ultrasonography of Inferior Thyroid Artery and Its Relation with Thyroid Functional State

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**Background:** Not enough information has been gathered regarding the parameters of color Doppler ultrasonography (CDU) for evaluating diffuse thyroid disorders in Taiwan. The aims of this study were to compare the CDU parameters between the right and left inferior thyroid arteries (ITAs), and to investigate which CDU parameters can differentiate between euthyroid and hyperthyroid glands.

**Patients and Methods:** We retrospectively reviewed data from patients who had undergone CDU to image thyroid disorders from December 2003 to April 2004 in order to analyze the CDU parameters that can be used to evaluate bilateral ITA. The mean age of the patients was 40.8 ± 16.6 years (range, 10–72 years). The female to male distribution was 2.2:1 (43 females and 20 males). The ITA of patients with normal thyroid, simple goiter and autoimmune thyroid disease were scanned with CDU. The parameters evaluated included pulsatility index (PI), resistive index (RI), peak systolic velocity (PSV), blood volume flow (VF) and diameter (Diam) of ITA. We then evaluated the relationships among these parameters between the right and the left ITAs and differences in parameters between patients with euthyroidism and hyperthyroidism. Significant parameters were analyzed by the *t* test and simple linear regression.

**Results:** There was good Pearson's correlation among all parameters (PI, RI, PSV, VF and Diam) ($p < 0.001$) between the right and left ITAs in all 63 patients. No significant differences were noted between the right and left ITAs ($p > 0.05$). These same results were seen in patients with euthyroidism (30 patients) and hyperthyroidism (27 patients), except that Diam of ITA had poor correlation between both sides in the hyperthyroid group. The CDU parameters of ITA were higher in patients with hyperthyroidism than in those with euthyroidism.

**Conclusion:** There were no significant differences in CDU parameters between the right and left ITAs. However, all parameters had higher values in patients with hyperthyroidism than in those with normal thyroid function. Therefore, we conclude that unilateral ITA CDU can be used to evaluate diffuse thyroid disorder. A large-scale study is needed to investigate which CDU parameters can be used to differentiate between euthyroid and hyperthyroid status in clinical practice.

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**KEY WORDS** — blood volume flow, color Doppler ultrasonography, peak systolic velocity, resistive index

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## Introduction

Thyroid glands contain feeding arteries and draining veins [1]. At least four main thyroid arteries supply both lobes of thyroid tissue; these include two superior thyroid arteries (STAs) and two inferior thyroid arteries (ITAs). Color Doppler ultrasonography (CDU) is widely used to evaluate the condition of the thyroid glands [2] and can be performed easily at bedside without exposing the patient to harmful radiation.

Hypervascularity in thyroid parenchyma is seen in patients with autoimmune thyroid diseases (AITD) such as Graves' disease and Hashimoto's thyroiditis, and especially in those with hyperthyroidism [1–7]. CDU is a useful modality for evaluating the progression of these diseases.

Obtaining CDU spectra of ITA for both lobes of the thyroid is time-consuming. In normal thyroid, the right lobe is larger and more vascularized than the left lobe [4]. In this study, ultrasonographic data of thyroid were analyzed to compare the CDU parameters, and furthermore to see whether the parameters differed between the left and right ITAs. We then aimed to determine if the parameters could be used to distinguish between euthyroid and hyperthyroid status.

## Patients and Methods

### *Patients*

We retrospectively analyzed the CDU parameters from a total of 434 ultrasound examinations that had been performed on 415 patients to evaluate thyroid disorders from December 2003 to April 2004 at the Chia-Yi Chang Gung Memorial Hospital (CY-CGMH). The female to male distribution of patients was 3.8:1 (328 females and 87 males). Patients ranged in age from 4 to 83 years, with a mean ± standard deviation (SD) of 45.1 ± 16.5 years. Of the 415 patients, 63 underwent CDU of bilateral ITA. Of the 63 patients, eight had normal thyroid glands. Patients who underwent CDU ranged in age from 10 to 72 years (mean ± SD, 40.8 ± 16.6 years). The female to male ratio was around 2.2:1 (43 females and 20 males). The mean age of female patients was 41.2 ± 16.0 years and that of males was 39.9 ± 18.1 years.

### *Thyroid evaluation*

Ultrasonographic studies of thyroid glands were performed with a real-time ultrasonographic scanner using a 10-MHz multifrequency linear probe (LOGIQ-9; GE Medical Systems, Milwaukee, WI, USA) and the following settings: color pulse repetition frequency, 2–8 kHz; wall filter, 25–80 Hz; and Doppler frequency, 4.4–6.6 MHz. Both the STAs and ITAs are small in diameter. The ITA lies below the thyroid bed and is more conspicuous and easier to be checked than the STA in clinical practice. CDU was performed to measure the parameters of ITA in patients with normal thyroid, simple goiter, and AITD. The parameters had been calibrated automatically and included pulsatility index (PI), resistive index (RI), peak systolic velocity (PSV), blood volume flow (VF) and ITA diameter (Diam). The data were excluded if the CDU spectra contained too many artifacts. Thyroid functions including thyroxin (T4), triiodothyronin (T3) and thyroid-stimulating hormone (TSH) were determined by radioimmunoassay (RIA) methods. The CDU parameters for the right and left ITAs were evaluated to see if they differed between the right and left thyroid arteries and to assess whether the parameters correlated with thyroid function.

### *Diagnostic criteria of hyperthyroidism and exclusion criteria*

Patients meeting the following diagnostic criteria of hyperthyroidism were included in the study [8]: (a) clinical signs and symptoms of hyperthyroidism such as palpitation, hand tremor, weight loss, heat intolerance, exophthalmos, and diffuse goiter, and (b) elevated serum T3 and T4 levels with a depressed serum TSH level. Patients with a history of thyroidectomy, $^{131}$I therapy or pregnancy were excluded from the study.

### *Statistical analysis*

Student's *t* test and simple linear regression (Pearson's correlation) were used to compare the vascular parameters between the right and left ITAs and between euthyroidism and hyperthyroidism. All calculations were performed with SPSS version 10.0 (SPSS Inc., Chicago, IL, USA) software. A *p* value less than 0.05 was considered significant.

## Results

### *Comparison of CDU parameters between the right and left ITAs in all patients*

Among the 63 patients, 30 euthyroid patients (including 8 normal thyroid, 7 simple goiter and 15 AITD), 27 hyperthyroid patients and three hypothyroid patients were diagnosed at the time they underwent ultrasonography. Three patients had no thyroid function data. CDU images in patients with hyperthyroidism essentially revealed more vascularity in the thyroid parenchyma and had higher parameter values than CDU images of patients with euthyroidism (Figs. 1 and 2)

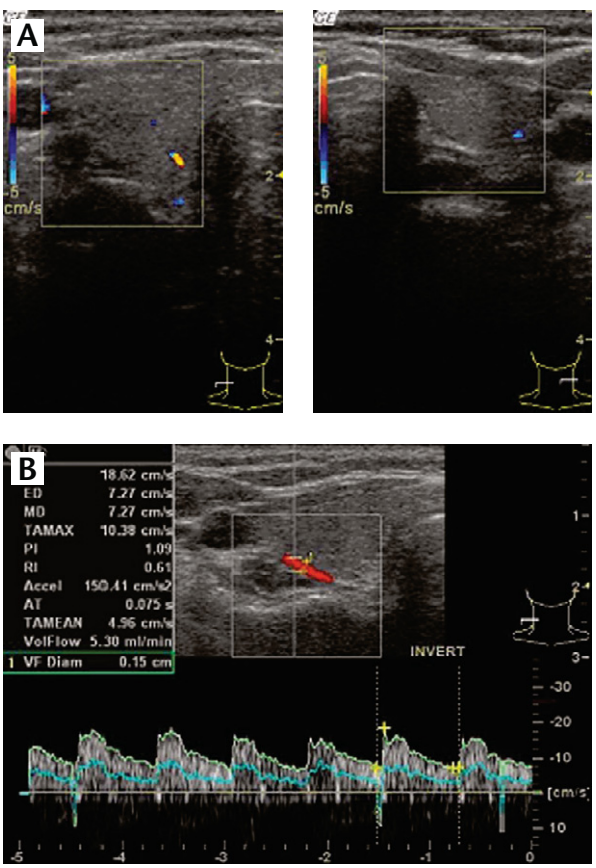


**Fig. 1.** *(A) Color Doppler ultrasonography and (B) pulse spectra of inferior thyroid arteries in an euthyroid patient show isovascularity with relatively low parameter values.*

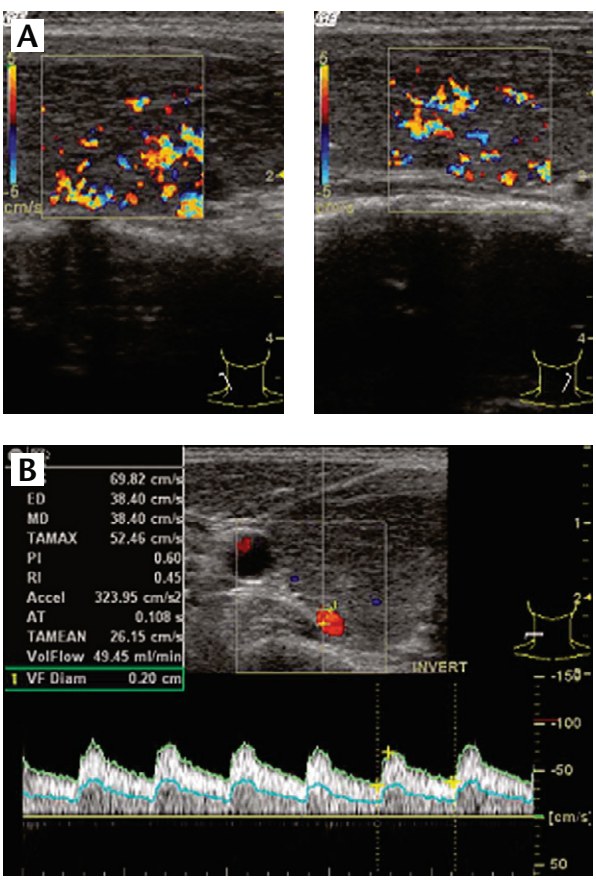


**Fig. 2.** *(A) Color Doppler ultrasonography and (B) pulse spectra of inferior thyroid arteries in a hyperthyroid patient show hypervascularity with relatively high parameter values.*

**Table 1.** Comparison between right (Rt) and left (Lt) inferior thyroid arteries with respect to the parameters of color Doppler ultrasonography in a total of 63 patients and euthyroid and hyperthyroid subgroups*

| | Total ($n=63$) | | | | Euthyroid ($n=30$) | | | | Hyperthyroid ($n=27$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | Mean ± SD | $t$ | $p$ | Site | Mean ± SD | $t$ | $p$ | Site | Mean ± SD | $t$ | $p$ |
| PI | Rt | 0.86 ± 0.34 | −1.519 | 0.134 | Rt | 0.76 ± 0.22 | −1.923 | 0.064 | Rt | 0.97 ± 0.43 | −0.567 | 0.576 |
| | Lt | 0.91 ± 0.29 | | | Lt | 0.85 ± 0.26 | | | Lt | 1.01 ± 0.33 | | |
| RI | Rt | 0.55 ± 0.16 | −0.892 | 0.376 | Rt | 0.51 ± 0.12 | −1.879 | 0.070 | Rt | 0.59 ± 0.21 | 0.174 | 0.863 |
| | Lt | 0.57 ± 0.11 | | | Lt | 0.55 ± 0.11 | | | Lt | 0.58 ± 0.12 | | |
| VF | Rt | 22.7 ± 28.1 | 1.521 | 0.133 | Rt | 18.3 ± 25.6 | 1.582 | 0.125 | Rt | 29.5 ± 32.5 | 0.432 | 0.670 |
| | Lt | 18.8 ± 23.1 | | | Lt | 13.4 ± 14.3 | | | Lt | 27.4 ± 30.1 | | |
| Diam | Rt | 0.18 ± 0.06 | 1.924 | 0.059 | Rt | 0.16 ± 0.05 | 1.285 | 0.209 | Rt | 0.20 ± 0.06 | 1.324 | 0.197 |
| | Lt | 0.17 ± 0.06 | | | Lt | 0.15 ± 0.05 | | | Lt | 0.19 ± 0.06 | | |
| PSV | Rt | 34.9 ± 22.9 | 0.588 | 0.558 | Rt | 30.2 ± 24.8 | 0.770 | 0.447 | Rt | 40.9 ± 21.4 | −0.400 | 0.692 |
| | Lt | 33.4 ± 23.4 | | | Lt | 27.4 ± 19.6 | | | Lt | 42.6 ± 26.0 | | |

**Paired samples t statistics test, all p > 0.05. SD = standard deviation; PI = pulsatility index; RI = resistive index; VF = volume flow (mL/min); Diam = diameter (cm); PSV = peak systolic velocity (cm/sec).*

There were no significant differences in the descriptive statistics of parameters (mean ± SD) between the right and left ITAs: PI (0.86 ± 0.34 *vs.* 0.91 ± 0.29, $p=0.134$), RI (0.55 ± 0.16 *vs.* 0.57 ± 0.11, $p=0.376$), VF (22.7 ± 28.1 *vs.* 18.8 ± 23.1 mL/min, $p=0.133$), Diam (0.18 ± 0.06 *vs.* 0.17 ± 0.06 cm, $p=0.059$), and PSV (34.9 ± 22.9 *vs.* 33.4 ± 23.4 cm/sec, $p=0.558$) (Table 1). Each parameter had good Pearson's correlation between right and left ITAs: PI ($r=0.545$), RI ($r=0.439$), VF ($r=0.696$), Diam ($r=0.557$), and PSV ($r=0.621$), all $p<0.001$ (Table 2).

### *Comparison of CDU parameters between the right and left ITAs in euthyroid patients*

There were a total of 30 euthyroid patients in this study. The female to male ratio was 23:7. The descriptive statistic values of PI and RI of the right ITA were smaller than those of the left ITA, but the difference was not significant: PI (right, 0.76 ± 0.22 *vs.* left, 0.85 ± 0.26; $p=0.064$) and RI (right, 0.51 ± 0.12 *vs.* left, 0.55 ± 0.11; $p=0.070$). The descriptive statistic values of other parameters did not differ significantly between the right and left ITAs: VF (18.3 ± 25.6 *vs.* 13.4 ± 14.3 mL/min, $p=0.125$), Diam (0.16 ± 0.05 *vs.* 0.15 ± 0.05 cm, $p=0.209$) and PSV (30.2 ± 24.8 *vs.* 27.4 ± 19.6 cm/sec, $p=0.447$) (Table 1). The CDU parameters correlated well with both ITAs: PI ($r=0.455$), RI ($r=0.437$), VF ($r=0.784$), Diam ($r=0.755$), and PSV ($r=0.612$); all $p<0.05$ (Table 2).

### *Comparison of CDU parameters between right and left ITAs in patients with hyperthyroidism*

A total of 27 patients (16 females and 11 males) had hyperthyroidism. The descriptive statistics of CDU parameters did not differ between the right and left ITAs: PI (0.97 ± 0.43 *vs.* 1.01 ± 0.33, $p=0.576$), RI (0.59 ± 0.21 *vs.* 0.58 ± 0.12, $p=0.863$), VF (29.5 ± 32.5 *vs.* 27.4 ± 30.1 mL/min, $p=0.670$), Diam (0.20 ± 0.06 *vs.* 0.19 ± 0.06 cm, $p=0.197$) and PSV (40.9 ± 21.5 *vs.* 42.6 ± 26.0 cm/sec, $p=0.692$) (Table 1).

Most of the parameters had good Pearson's correlation between both ITAs in hyperthyroid patients: PI ($r=0.534$, $p=0.004$), RI ($r=0.435$, $p=0.023$), VF ($r=0.659$, $p<0.001$), and PSV ($r=0.601$, $p=0.001$). Diam, however, did not have a good correlation ($p=0.083$) (Table 2).

### *Comparison of the average CDU parameters of the right and left ITAs between patients with hyperthyroidism and those with euthyroidism*

The average PI, Diam and PSV values of bilateral ITAs were significantly higher in patients with hyperthyroidism than in those with euthyroidism: 0.99 ± 0.34

**Table 2.** Correlations between right and left inferior thyroid arteries with respect to parameters of color Doppler ultrasonography in a total of 63 patients and euthyroid and hyperthyroid subgroups

| | Total ($n=63$) | | Euthyroid ($n=30$) | | Hyperthyroid ($n=27$) | |
|---|---|---|---|---|---|---|
| | Correlation | $p$ | Correlation | $p$ | Correlation | $p$ |
| PI | 0.545 | $<0.001$* | 0.455 | 0.012† | 0.534 | 0.004† |
| RI | 0.439 | $<0.001$* | 0.437 | 0.016† | 0.435 | 0.023† |
| VF | 0.696 | $<0.001$* | 0.784 | $<0.001$* | 0.659 | $<0.001$* |
| Diam | 0.557 | $<0.001$* | 0.755 | $<0.001$* | 0.339 | 0.083 |
| PSV | 0.621 | $<0.001$* | 0.612 | $<0.001$* | 0.601 | 0.001* |

**$p<0.001$, †$p<0.05$, paired samples Pearson's correlations. PI = pulsatility index; RI = resistive index; VF = volume flow; Diam = diameter; PSV = peak systolic velocity.*

**Table 3.** Comparison of the parameters of color Doppler ultrasonography of inferior thyroid arteries between euthyroid and hyperthyroid patients

| | Euthyroid ($n=30$) Mean ± SD | Hyperthyroid ($n=27$) Mean ± SD | $t$ | $p$ |
|---|---|---|---|---|
| PI | 0.81 ± 0.20 | 0.99 ± 0.34 | −2.511 | 0.016* |
| RI | 0.54 ± 0.09 | 0.59 ± 0.14 | −1.747 | 0.086 |
| VF (mL/min) | 15.8 ± 18.9 | 28.4 ± 28.5 | −1.987 | 0.052 |
| Diam (cm) | 0.16 ± 0.05 | 0.20 ± 0.05 | −3.064 | 0.003* |
| PSV (cm/sec) | 28.8 ± 20.0 | 41.8 ± 21.3 | −2.376 | 0.021* |

**$p<0.05$, independent two samples t test. SD = standard deviation; PI = pulsatility index; RI = resistive index; VF = volume flow; Diam = diameter; PSV = peak systolic velocity.*

*vs.* 0.81 ± 0.20, 0.20 ± 0.05 *vs.* 0.16 ± 0.05 cm and 41.8 ± 21.3 *vs.* 28.8 ± 20.0 cm/sec, respectively ($p<0.05$). The average RI and VF values were higher in patients with hyperthyroidism than in those with euthyroidism, but the differences were not significant ($p>0.05$) (Table 3).

## Discussion

Two STAs and two ITAs supply the thyroid gland. In a normal thyroid, the right lobe is larger and more vascularized than the left lobe [4]. However, Tegler et al [9] revealed through an electromagnetic flowmetry study that there was no significant difference in blood flow between the right and left thyroid arteries or between the STA and ITA. Hodgson et al [3] reported similar findings in CDU spectral studies. No significant differences were noted for VF and Diam parameters between right and left STAs in euthyroid patients. Both ITAs and STAs are thin. Obtaining CDU spectra of both ITAs and STAs for both lobes of the thyroid is time-consuming and not practical in an outpatient clinic. We performed the blood flow measurements on the ITAs because of their conspicuous contribution to thyroid vascularization [6] and because it is easier to check when compared to STA. Our results revealed similar findings for VF and Diam parameters between the right and left ITAs. Reported mean values of VF range from 5.5 ± 1.7 to 18 ± 6.0 mL/min in euthyroid patients [3,10,11]. In our study, the mean VF was 15.8 ± 18.9 mL/min (Table 3). A higher mean VF (28.4 ± 28.5 mL/min) value in our study was found in patients with hyperthyroidism than in those with euthyroidism (Table 3). However, higher and variable VF values, ranging from 73 ± 34.3 to 150 mL/min have been reported [3,10–12].

The diameter of ITA is one of the main factors that affect the measurement of VF. In our experience, it is difficult to obtain optimal CDU spectra in normal thyroid or simple goiter because the ITA is very thin. Hodgson et al [3] reported that the mean diameter of STA in healthy patients measured $0.15 \pm 0.02$ cm and no differences were found between the right and left STAs. We found similar diameters in our measurement of ITA in euthyroid patients (Diam, $0.16 \pm 0.05$ cm) and larger ITAs in patients with hyperthyroidism (Diam, $0.20 \pm 0.05$ cm) (Table 3).

Krejza et al [13] reported that the PI of STA was $0.85 \pm 0.23$ in healthy women. Wang and Chang [6] found that patients with hyperthyroidism and poorly controlled Graves' disease have higher PI values (PI = 1.36 and 1.24, respectively), whereas patients who were withdrawn from therapy and those with euthyroidism have lower PI values (PI = 0.78 and 0.76, respectively). In our ITA study, the value of PI in the euthyroid group (averaged PI of bilateral ITA = $0.81 \pm 0.20$) was lower than that in the hyperthyroid group ($0.99 \pm 0.34$) (Table 3).

According to Chou et al [2], there were no significant differences between right and left ITAs or between normal females and males in RI and PSV estimations. Caruso et al [14] reported that the PSV values did not differ significantly between the right and left ITAs in patients with Graves' disease, or in patients with Hashimoto's thyroiditis.

Noise interference is more of a problem when calculating PI than when calculating RI; therefore, RI is a more reliable measurement than PI [6]. RI values of STA in healthy women were $0.55 \pm 0.08$ in Krejza et al's study [13], whereas those of ITA in healthy women were $0.6 \pm 0.06$ in Chou et al's study [2]. Wang and Chang [6] reported that RI values could be used to determine the therapeutic method for Graves' disease using a 7.5-MHz transducer. Higher RI levels were found in hyperthyroid patients (0.74–0.79) but lower levels were seen in euthyroid patients (0.56–0.57). They concluded that patients with RI values above 0.7 should undergo ablative therapy. However, Castagnone et al [10] reported that there was no significant difference in RI values between hyperthyroid patients ($0.54 \pm 0.03$ to $0.63 \pm 0.06$) and euthyroid patients ($0.55 \pm 0.02$ to $0.61 \pm 0.03$) ($p = 0.37$) when ITA was measured with a 5.0-MHz transducer. In our study, we measured ITA with a 10-MHz transducer. We found that the mean ± SD of RI in euthyroid patients ($0.54 \pm 0.09$) was slightly lower than that in hyperthyroid patients ($0.59 \pm 0.14$), but the difference was not significant ($p > 0.05$) (Table 3). Therefore, the conflicting results may be due to the different frequencies of transducers used in Castagnone et al's (5.0 MHz), Wang and Chang's (7.5 MHz) and our studies (10 MHz).

In our study, the average PSV value of normal ITA ranged from $24.6 \pm 6.0$ to $26.7 \pm 7.6$ cm/sec [2,10]; however, higher ($50 \pm 10$ cm/sec) [13] and lower ($17.7 \pm 3.3$ cm/sec) [7] values have been reported. In our studies, the PSV value of ITA in euthyroid patients was $28.8 \pm 20.0$ cm/sec, whereas the PSV value of ITA in hyperthyroid patients was $41.8 \pm 21.3$ cm/sec (Table 3). PSV values range from $42.1 \pm 14.6$ to $186 \pm 38.7$ cm/sec in the literature [7,14]. Different ultrasonography settings and different frequencies of transducers may contribute to these different results.

In conclusion, CDU parameters do not differ significantly between the right and left lobes of the thyroid gland. Furthermore, we found that CDU parameters had a good correlation between both lobes of ITA. ITA parameters are higher in patients with hyperthyroidism than in those with euthyroidism. Therefore, ITA is useful for evaluating thyroid functional status to differentiate hyperthyroidism from euthyroidism. Since there is no significant difference in CDU parameters between the right and left ITAs, we propose that parameters of one side can be used to evaluate the clinical condition of patients with thyroid disorders. Further large-scale study is needed to confirm our findings.

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## References


1. Sandler MP, Rao BK, Patton JA, et al. Thyroid imaging. In: Sandler MP, Patton JA, Gross MD, et al, eds. *Endocrine Imaging.* Norwalk: Appleton & Lange, 1992: 175–223.
2. Chou YH, Chiou HJ, Tiu CM, et al. Spectral pulsed Doppler blood flow measurement of normal inferior thyroid arteries. *J Med Ultrasound* 2001;9:119–22.
3. Hodgson KJ, Lazarus JH, Wheeler MH, et al. Duplex scan-derived thyroid blood flow in euthyroid and hyperthyroid patients. *World J Surg* 1988;12:470–5.
4. Larsen PR, Davies TF, Schlumberger MJ, et al. Thyroid physiology and diagnostic evaluation of patients with thyroid disorders. In: Larsen PR, Kronenberg HM, Melmed S, et al, eds. *Williams Textbook of Endocrinology*, 10th edition. Philadelphia: WB Saunders, 2003:331–74.
5. Ralls PW, Mayekawa DS, Lee KP, et al. Color-flow Doppler sonography in Graves' disease: "thyroid inferno". *AJR Am J Roentgenol* 1988;150:781–4.
6. Wang CY, Chang TC. Thyroid Doppler ultrasonography and resistive index in the evaluation of the need for ablative or antithyroid drug therapy in Graves' hyperthyroidism. *J Formos Med Assoc* 2001; 100:753–7.
7. Vitti P, Rago T, Mazzeo S, et al. Thyroid blood flow evaluation by color-flow Doppler sonography distinguishes Graves' disease from Hashimoto's thyroiditis. *J Endocrinol Invest* 1995;18:857–61.
8. Chiou SC, Houng HS, Li KL, et al. Outcome of Graves' thyrotoxicosis after antithyroid drug treatment. *Chang Gung Med J* 1995;18:305–14.
9. Tegler L, Gillquist J, Anderberg B, et al. Thyroid blood flow rate in man. Electromagnetic flowmetry during operation in euthyroid normal gland, nontoxic goiter and hyperthyroidism. *J Endocrinol Invest* 1981;4:335–41.
10. Castagnone D, Rivolta R, Rescalli S, et al. Color Doppler sonography in Graves' disease: value in assessing activity of disease and predicting outcome. *AJR Am J Roentgenol* 1996;166:203–7.
11. Saleh A. Cervical lymph nodes and thyroid. In: Hofer M, ed. *Teaching Manual of Color Duplex Sonography,* 2nd edition. New York: Georg Thieme Verlag, 2004:27–32.
12. Baldini M, Castagnone D, Rivolta R, et al. Thyroid vascularization by color Doppler ultrasonography in Graves' disease. Changes related to different phases and to the long-term outcome of the disease. *Thyroid* 1997;7:823–8.
13. Krejza J, Nowacka A, Szylak A, et al. Variability of thyroid blood flow Doppler parameters in healthy women. *Ultrasound Med Biol* 2004;30:867–76.
14. Caruso G, Attard M, Caronia A, et al. Color Doppler measurement of blood flow in the inferior thyroid artery in patients with autoimmune thyroid diseases. *Eur J Radiol* 2000;36:5–10.


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